

NASA BENEFITS BRIEFING NOTEBOOK

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## PREFACE

"Space Benefits" has been prepared for the NASA Technology Utilization Office by the Denver Research Institute, "Program for Transfer Research and Impact Studies," to provide the Agency with accurate, convenient, and integrated resource information on the transfer of aerospace technology to other sectors of the U.S. economy.

The contents of this notebook are divided into two sections: (1) Benefit Cases and (2) Indexes. The transfer examples section is subdivided into eleven subject areas; the Table of Contents identifies those areas. Each subsection presents one or more key issues of current interest in the discrete transfer cases related to each key issue. Finally, additional transfer examples relevant to each subject area are presented. Pertinent transfer data are given at the end of each example (viz., the communication link; the Transfer Example File and individual case numbers; and the date of the latest information used).

Since we are evolving this document, this book will be updated, expanded and reprinted periodically as new materials become available.

The reader should keep in mind that the status of technology transfer documented within these pages reflects the best available information at a particular point in time. In fact, additional activity may have occurred beyond the date of each example. Detailed information of transfer examples briefly described in this document can be obtained, upon request, from the Technology Utilization Office, Code KT, NASA Washington, D.C. 20546.

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Director  
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## A. MANUFACTURING CONSUMER PRODUCTS

### Key Issues

- a. Consumer product R&D: 1973 McGraw-Hill Economics Department survey of industrial R&D expenditures indicated continuing decline as % of sales (2.5% of sales in 1972, 2.4% in 1973, projected 2.3% by 1976) and significant shift from new product or process development to improving products or processes. 44% of manufacturers surveyed reported product improvement as main R&D goal and 73% did not anticipate a technological or basic research breakthrough by 1976. Previous 1972 survey indicated that new products would account for 18% of total sales in 1975, 1973 survey now indicates they will account for 13% in 1976. (A-1)
- b. Productivity: Average annual increase in output per man-hour was 3.1% (1955-1966), 1.7% (1967-1970), 3% (1971-1972). Bureau of Labor Statistics estimates that decrease of 0.1% in average productivity between 1970 and 1980 would cause GNP to be \$60 billion less than potential. Productivity expert Professor John Kendrick (George Washington University) stated that 1967-1970 slump was due to slow-down in government funding as % of GNP, which peaked in 1964, and since then "growth in the stock of knowledge has been decelerating." Upturn in 1971 attributed by Business Week (1/1/72, p. 36) to new worker hiring lag at beginning of business boom, only a short-term effect. (A-4)

## A. MANUFACTURING CONSUMER PRODUCTS

- \*A-1 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product purchased by B.F. Goodrich Tire Co. (Ohio) and regularly used for consumer product R&D. . . . applications include analyzing tire designs and causes of tire fatigue, identifying tire design and construction flaws, and investigating how heat shortens service life for V-belts, shock mounts, brakes and rubber bearings. . . . scanner enables researchers to observe and record heat build-up during product testing so designs or production processes can be improved. . . . 1973 R&D funding by rubber products industry was about \$200 million (1.1% of sales), large part directed toward product improvement. (Customer/contractor, TEF 398, Case No. 70001, 8/74)
- A-2 Management method for R&D programs: developed for Marshall. . . . used by The Upjohn Co. (Michigan) to develop management method for its pharmaceutical research programs. . . . saved Upjohn substantial man-hours. (TB/TSP, TEF 452, Case No. 60860, 8/74)
- A-3 Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing composite products. . . . orders of nearly \$1 million in 1973. . . . products used in golf club shafts and business machines. (Trade Journal/TSP, TEF 490, Case No. 87986, 2/74)
- \*A-4 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Alabama). . . . integral part of industrial monitoring system developed by SCI. . . . entire industrial system similar to Saturn instrument monitoring system. . . . SCI system installed in most U.S. textile weaving mills built between 1968 and 1971, 17 installations by SCI in price range \$65,000 to \$100,000, at least 4 more installed by ex-SCI employees working for West Point-Pepperell, Inc. (Georgia). . . . product line sold to Swiss company in 1971, with same technology used in many new textile weaving mills worldwide (particularly, Poland, France, Belgium and U.S.). . . . system monitors loom operator performance and is wholly responsible for productivity increases over 1%, generally in 2-6% range. . . . annual national productivity increase was 1.7% between 1967 and 1970, 3% before and after that time period. (Contractor, TEF 119, Case No. 04793, 9/74)
- A-5 Contamination control handbook: compiled for Marshall. . . . used by Ortho Pharmaceutical Co. (New Jersey) to design better contamination control facilities for birth control pill production. . . . increased worker productivity . . . . used by Kentucky Electronics, Inc. (Kentucky) to improve two key production steps for consumer electronics (mainly color television components for RCA, Westinghouse and Zenith products), degreasing and drying operations now done with fluids and processes described in handbook. . . . improved product quality and productivity, with annual sales over \$7 million. (TB/TSP, TEF 262, Case Nos. 31286, 39662, 9/74)

\* Denotes transfer case related to Key Issue.

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#### A. MANUFACTURING CONSUMER PRODUCTS (CONT.)

- A-6 Method to improve electrical resistors with hydrogen: developed for Headquarters. . . . used by Zeller Corp. (Ohio) to develop automated process for resistor spark plug production. . . . automation saves 4 cents per unit and over 500,000 sold annually since 1972. (SBA/TSP, TEF 468, Case No. 88432, 8/74)
- A-7 Optical alignment training manual: compiled by Marshall. . . . incorporated into standard operating procedures at Eastman Kodak Co. (New York) for aligning optical testing instruments. . . . accuracy improved. (TB/TSP, TEF 208, Case No. 32414, 8/74)

#### Other Relevant Examples:

B-9 (lubricant deposition process); C-5 (fabric metallizing process); F-2 (product safety); H-11 (automobile fuel R&D); I-5 (home safety product); K-3, K-4 and K-5 (automobile design and production)

## B. MANUFACTURING CAPITAL GOODS

### Key Issue

Balance of trade for capital goods: In 1973, U.S. exported capital goods worth \$21.5 billion and imported \$7.5 billion. Exports of electrical machinery and electronic components accounted for \$3.5 billion, more than any other classified capital goods. U.S. supplied over two-thirds of growing world market for microelectronic components. Market share maintained by continually advancing the state-of-the-art of microelectronic component production technology so that productivity is increased. Productivity depends on yield which is improved by reducing the percentage of components spoiled during production. (B-1)

## B. MANUFACTURING CAPITAL GOODS

- \*B-1 Microelectronics production quality assurance: NASA established reliability program and procurement standards for microelectronic products in 1964 to assure best manufacturing practices would be used by suppliers. . . . introduced concept of Certified Production Line (CPL) so that entire production lines, rather than products themselves, were certified for NASA procurement after vendor had established quality control practices and in-house evaluation methods to satisfy NASA inspection teams. . . . CPL approach later adopted by DOD which developed, with NASA, certification standards. . . . many major microelectronics manufacturers configured standard production lines to be certified for space or defense procurement and now produce commercial units from these lines. . . . widespread impact by increasing productivity for commercial products on world market. . . . one vendor increased yield by 20% after modifying production practices for certification (1-2% increases very valuable in the industry). . . . Marshall obtained one of first scanning electron microscopes (SEM) ever built and developed SEM inspection techniques to analyze failure modes for microelectronics. . . . provided failure analysis reports to microelectronic vendors and encouraged manufacturers to use SEM for same purpose. . . . SEM's now widely used in U.S. microelectronics industry. . . . largest producer of microelectronics, Texas Instruments (Texas), with annual sales over \$1 billion, is certified by NASA and used 3 SEM's for quality assurance and failure analysis. . . . NASA standards used in key production steps for all TI products. (Contractor, Industrial Products and Practices, DRI, 2/73)
- B-2 Infrared scanner and television display: operational unit developed for Marshall. . . . contractor employees founded Dynarad, Inc. (Massachusetts) to market unique product line of IR scanners. . . . units display heat picture on TV screen. . . . over \$2 million in total sales, unit price range \$6,500 to \$25,000. . . . customer applications include maintenance inspections, quality control, and research in several industries (steel, aluminum, petrochemical, rubber, nuclear fuels, aircraft and electric power) as well as medical diagnoses such as breast cancer. (Personnel/contractor, TEF 398, Case No. 70001, 8/74)
- B-3 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over \$2 million in contracts to produce innovative NASA equipment in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed. . . . uses multiple transducers for significant improvement in speed and accuracy. . . . more than 25 manufacturers purchased between 1 and 100 Manipulators @ \$800. . . . larger number of firms fabricated in-house versions. . . . widely used for quality control inspection of aircraft components and steel pipe manufactured for petrochemical applications. . . . Automation has \$50 million annual sales of ultrasonic test equipment for quality control in steel, railroad, aircraft, nuclear reactor, automotive, and tubular products industries. (Contractor, TEF 387, Case No. 59201, 8/74)

\* Denotes transfer case related to Key Issue.

## B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-4 Nondestructive testing handbook: developed by Marshall. . . . ultrasonic techniques in handbook provided 10-30% of input to development of in-house quality control procedures at Aluminum Company of America (Pennsylvania) . . . . ultrasonic testing routinely done for wrought aluminum products at Alcoa plants. . . . ultrasonics faster, better resolution than other NDT methods in finding flaws, very important link to fracture mechanics since brittle fracture can start at flaws left by fabrication process. (TUO conference, TEF 381, Case No. 57802, 8/74)
- B-5 Contamination control handbook: compiled for Marshall. . . . used at Xerox Data Systems (California) to improve contamination control in production of computer peripherals such as disc files. . . . reduced cost of contamination control and significantly reduced quality control failure rate caused by contamination. (TB/TSP, TEF 262, Case No. 33050, 10/72)
- B-6 Surface finishing method for nickel alloys: developed for Marshall. . . . standard process at Westinghouse Corp. (Pennsylvania) since 1970 to finish components for gas turbine electric generators. . . . turbines up to 100 megawatts. . . . significant time and cost savings over previous method. (TB/TSP, TEF 198, Case No. 29518, 8/74)
- B-7 Inert-gas welding enclosure: developed by Lewis. . . . used by Communications Satellite Corp. (District of Columbia) to fabricate microwave components for satellites and ground stations. . . . made it possible to use very lightweight metals for components and reduce production time ten-fold. (TB/TSP, TEF 189, Case No. 19795, 8/74)
- B-8 Fluidic controls: developed by Lewis for rocket engines. . standard controller on automatic metalworking lathes produced by Bardons and Oliver, Inc. (Ohio) since 1967. . . . only fluidic-controlled lathes on market. . . . 125 sold in price range \$40,000 to \$80,000. . . . fluidic controls are half the cost of electric controls, also more reliable and maintainable. (TUO conference, TEF 193, Case No. 101902, 8/74)
- B-9 Lubricant deposition process: developed for Goddard by Bail Brothers Research Corp. (Colorado). . . . process commercialized by BBRC into VacKote line of several hundred lubricant products. . . . 1973 sales \$1 million and annual growth 25%. . . . over \$100,000 from license royalties. . . . 300 industrial customers. . . . customer examples: coating for glass industry molds increases production efficiency 5% and eliminates prior fire hazard; protective film coating for movie camera film cartridges improves performance and reduces film breakage; lubricant for electric motor brushes in vacuum cleaners, electric shavers, and car air conditioners increases service life; and lubricant for computer peripheral equipment increases efficiency. (Contractor, TEF 201, Case No. 42849, 8/74)

## B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-10 Fracture toughness tests: developed by Lewis. . . . used by Aluminum Company of America (Pennsylvania) to provide fracture toughness guarantee for high-strength alloy products. . . . critical design parameter for Alcoa customers who use these alloys to fabricate aircraft components, chemical processing equipment, or liquefied natural gas containers on ocean tankers. . . . reduces structural failures. (Professional society, TEF 451, Case No. 101901, 8/74)
- B-11 Thermal expansion properties handbook: compiled for Marshall. . . . used extensively at Kodak chemical plant (Tennessee) in design and materials selection for new hydrogen production facility worth over \$500,000. . . . saved 25% of design cost and significant amount of construction cost. . . . also used to select better materials for catalytic cracker and heat exchanger. (TB/TSP, TEF 321, Case No. 32416, 3/71)
- B-12 Weld strength prediction method: developed for Marshall. . . . used at Kodak chemical plant (Tennessee) to improve safety at little cost. . . . eliminated hazard of rupturing pipes that contain chemicals. (TB/TSP, TEF 359, Case No. 41946, 3/71)
- B-13 Fan noise reduction method: developed for Lewis Quiet Engine Program. . . . used by Kennecott Copper Corp. (Utah) to design inexpensive acoustic panels for fans in copper refineries. . . . enabled company to comply with noise level regulations set by Occupational Safety and Health Administration (OSHA). . . . significant savings compared to alternative of replacing older fans. (TB/TSP, TEF 476, Case No. 81646, 8/73)

### Other Relevant Examples:

A-3 (office equipment); C-1 (energy conservation equipment); D-3 (dispatch computers, electric power); D-6 (nuclear power plant equipment design); D-7 (steam turbine, steam generator and high temperature gas-cooled reactor design); D-9 (nuclear power plant design); F-2 (farm tractors and implements); H-2, H-3 and I-6 (LNG storage and transfer facilities); H-4 and H-5 (process control systems); H-6 (heat pipes); H-10 (gasoline vapor condenser)

### C. NEW CONSUMER PRODUCTS AND RETAILING

#### Key Issues

- a. New product introduction: New products have been a major source for corporate growth. Industrial trend is now toward introducing fewer new products and reducing production costs to maintain profitability (see Key Issue A-a). Booz, Allen and Hamilton estimates that only 2% of new product ideas are successfully commercialized. A recent study of 500 successful innovations showed 75% were based on market demand or production need, rather than technical feasibility. Even with market demand, a new consumer product may not be profitable if return on investment is inadequate. Dr. T. R. Hopkins, president of Gulf Research and Development Co., said in 1973 speech that product research is out-pricing itself since research costs are 10% of the investment to manufacture a new product. (C-1)
- b. Automation in department store sales: Retail sales by department stores were \$37.3 billion in 1970 and will be about \$55.5 billion in 1974; this represents 10% of total retail sales. Between 1970 and 1974 there was a 30% increase in department store sales per employee. One factor in this productivity increase is the rapid proliferation of computerized point of sale (POS) equipment such as cash register and credit authorization terminals. Over 250,000 POS terminals are being used by retailers. Many of the terminals are linked to approximately 75 major, on-line computer systems that have been installed by department store chains such as J.C. Penney and Montgomery Wards. POS equipment sold in 1973 had an estimated value of \$70 million; expected payback time for the equipment cost is 3 to 4 years. Advantages include reduced operating costs, improved inventory control, more detailed merchandising information, and faster, more accurate sales transactions. (C-9)

### C. NEW CONSUMER PRODUCTS AND RETAILING

- \*C-1 Heat pipe technology: developed for NASA by Los Alamos Scientific Labs and others. . . . based on availability of NASA R&D results from a Regional Dissemination Center, Isothermics, Inc. (New Jersey) was formed in 1971 to market heat pipe products. . . . five product lines introduced and successful . . . . \$700,000 sales in 1972, over \$1.5 million sales in 1974. . . . over half of sales are for Air-O-Space and Thermo-Coil, heat pipes that recover waste heat from furnace flue gas. . . . Air-O-Space for home furnaces, 10,000 sold in 1974 @ \$100. . . . Thermo-Coil for industrial furnaces, dryers, etc., just introduced, projected annual market doubling and \$2 million sales in 1976. . . . products increase heat efficiency by 8-10%, relevant to new consumer demand. . . . Isothermics capturing large market share early in trend toward energy conservation equipment. (RDC-TAC, TEF 197, Case No. 83601, 9/74)
- C-2 Anti-fog compound: developed for Johnson. . . . prevents condensation fogging on transparent surfaces. . . . more than 60 NASA licenses issued. . . . sold by Western Fire Equipment Co. (California) for fire fighters' face shields, air masks and for protective goggles. . . . marketed by others for eyeglasses, diver's masks, ski goggles. . . . known sales exceed \$500,000. (TB/TSP, TEF 423, Case No. 81857, 8/74)
- C-3 Rogallo airfoil design: developed by Langley Research Center for rocket recovery. . . . used by Free Flight Systems (California) and others to design hang gliders for recreational use. . . . Rogallo design used on 90% of all hang gliders. . . . Free Flight Systems is largest manufacturer of hang gliders. . . . 3,000 sold @ \$500. . . . rapidly growing sport. (Personal contact/JPL, TEF 499, Case No. 101900, 8/74)
- C-4 Battery-powered hand tools: developed for Johnson by Black and Decker (Maryland). . . . commercialized by B & D into line of 6 cordless power tools for home consumer (including 1/4" drill, 3 models of grass shears, 2 shrub and hedge trimmers). . . . direct improvement over previous line. . . . sales figures not available. (Contractor, TEF 300, Case No. 33607, 8/74)
- C-5 Aluminized mylar: basic patent by National Research Corp. in 1962. . . . first applications developed for Lewis (Echo I, spacecraft, space suits) . . . . commercial product, SPACE blanket, introduced by NRC in 1964. . . . NRC became Norton Co. division and metallized process extended to provide fabric coating service for companies, such as McGregor-Doniger, Inc. (New York), making ski parkas, coats, sleeping bags, life raft canopy. . . . annual sales for Norton coating service and products over \$2 million. . . . division sold to King-Seeley Thermos Co. (Massachusetts) in 1971. . . . products and process still being marketed, sales figures not available. (Contractor, TEF 160, Case No. 37434, 8/74)

• Denotes transfer case related to Key Issue.

C. NEW CONSUMER PRODUCTS AND RETAILING (CONT.)

- C-6 Active filter circuit design method: developed for Marshall. . . . circuitry and design procedures utilized by Computer Image Corp. (Colorado) in development of its Scanimate computer. . . . contributed to unit cost reduction from \$350,000 to \$300,000 each. . . . 1973 sales \$900,000. . . . 1973 service income \$2 million. . . . product used to generate computer animation for television advertising for Pontiac, Wards, Amoco, Kellogg, Black Label and Time magazine. (SBA/TSP, TEF 436, Case No. 56028, 8/74)
- C-7 Inflatable/nontippable life raft: developed by Langley for ocean recovery of astronauts. . . . commercialized by Winslow Co. (Florida) in conjunction with the individual who received exclusive NASA license to practice the invention. . . . survival equipment on pleasure boats/aircraft, U.S. Coast Guard vessels and some overseas airliners. . . . three models in price range \$210 to \$1,430, 1974 sales \$70,000. . . . company's life raft improves chance of safe rescue by providing radar reflective, thermally insulated metallized cloth cover. . . . cloth produced by King-Seeley Thermos Co. using other NASA technology. (License, TEF 131, Case No. 02440, 9/74)
- C-8 Chlorate candle oxygen supply: improved for Johnson. . . . Regional Dissemination Center provided information on chlorate candle technology to Pyro-netics, Inc. (California). . . . information used to develop portable welding torch product that incorporates chlorate candle oxygen supply. . . . approximately 100,000 units sold since 1972, retail price \$30. . . . product weighs 7 lbs. and gives a 5,000°F flame. . . . home and hobby applications. (RDC-WESRAC, TEF 466, Case No. 87123, 8/74)
- \*C-9 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized retail sales systems for department store chains. . . . largest supplier of such systems; has installed about 60 on-line computer systems (80% of total installations), with over 50,000 point of sale (POS) terminals connected to these systems. . . . typical system with 1,000 credit authorization terminals in 175 stores costs about \$1.5 million; average improvements over nonautomated methods include 95% reduction in purchases on bad debt accounts, 75% reduction in fraud purchases, 20% cost savings in payroll for authorization employees, and 33% reduction in telephone calls. . . . systems with POS cash register terminals also provide improved inventory control, more accurate and faster sales transactions, more detailed merchandising information, and better sales data for management analysis. . . . TRW customers include Montgomery Wards, May Co., Neiman-Marcus, J.C. Penney, Rich's, Burdine's, Hudson's Bay Co., and many more. (Contractor, TEF 465, Case No. 104260, 10/74)

\* Denotes transfer case related to Key Issue.

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C. NEW CONSUMER PRODUCTS AND RETAILING (CONT.)

Other Relevant Examples:

A-2 (golf club shafts); A-6 (resistor spark plugs); F-4 (high protein flour); F-5 and F-7 (packaged food quality); F-8 (beef merchandising innovation); F-9 (freeze-dried food); F-10 (frozen food quality); I-2 (geodesic domes); I-5 (home safety device); K-4 (automotive electronic ignition); K-5 (automotive gas turbine engine)

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#### D. ELECTRIC UTILITIES

##### Key Issues

- a. Pollution control: "The environmental crusade was the costliest phenomenon ever to batter the nation's electric utility industry" (Electrical World, 1974). Capital and operating costs for air pollution control were \$1.7 billion in 1971 and \$2.5 billion in 1973. (D-1)
- b. Dispatch computers: Electric utility market for computers growing at 20% annually; major trend is installation of real-time digital computers for dispatch and control of bulk power supply systems (interconnected generating stations). Digital dispatch provides economic, reliable operation of these power pools and prevents recurrence of 1965 Northeast Black-out. Approximately 20 dispatch computer systems installed or under contract. (D-3)
- c. Nuclear power plants: Nuclear generating capacity growing rapidly (from 6,000 Megawatts, or 2% of total, in 1970, to 475,000 Mw, or 40% of total, in 1990). Improved design methods being used to sustain trend toward larger nuclear plants (typically 200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). Annual capital investment in nuclear power was \$3.5 billion in 1972 and 1973. (D-6)

## D. ELECTRIC UTILITIES

- \*D-1 Combustion analysis computer programs: developed by Lewis and for Johnson . . . . used since 1970 by former space program combustion experts, KVB Engineering, Inc. (California), to design firing modifications for power plant fossil-fueled boilers. . . . reduced nitrogen oxide emissions by 40-70% in compliance with legal standards. . . . KVB has analyzed emissions from 160 large boilers, 100 small boilers and 30 ground power gas turbines . . . . over 100 large boilers modified for utilities nationwide, e.g., Southern California Edison Co., Los Angeles City Department of Water and Power, Consolidated Edison (New York), and Houston Lighting and Power Co. . . . pollution reductions by KVB method considerably less expensive than by any known alternative; little or no added operating costs. (Contractor, TEF 463, Case No. 86009, 9/74)
- D-2 Combustion analysis computer program: developed by Lewis. . . . used by Babcock and Wilcox Co. (Ohio) to modify utility boiler product designs for reduced nitrogen oxide emissions and to develop new sulfur dioxide removal system for power plant stack gases. . . . unique capability to analyze operating trends for experimental hardware, a guide in design improvements. (Personal contact/Lewis, TEF 463, Case No. 86016, 1/73)
- \*D-3 Apollo Guidance Computer software: developed for Johnson. . . . used by TRW Controls (Texas) to develop TRW Executive Program and other software for electric power dispatch computers. . . . provides real-time control capability in large, multi-tiered computer systems installed at General Public Utilities Corp. (Pennsylvania and New Jersey) and Arkansas Power and Light (\$500,000 installation). . . . also being installed at Public Service Co. of Oklahoma and Swedish State Power Board. . . . Apollo software also used by TRW Industrial Operations (California) to provide real-time control capability in new Bonneville Power Administration (Washington) dispatch computer system (\$5.2 million installation). . . . benefits cited by BPA include decreased blackouts and \$400,000 annual transmission savings . . . . TRW is second largest producer of dispatch computer systems in U.S. (Contractor, TEF 465, Case No. 86005, 8/74)
- D-4 Digital color television display: developed for Johnson Mission Control Center by Philco-Ford (Texas). . . . P-F developed commercial product for electric utility dispatch computer control center. . . . DCTV display installed at Cleveland Electric Illuminating Co. (Ohio), Houston Lighting and Power Co. (Texas) and Pennsylvania-New Jersey-Maryland power pool control centers. . . . product line sold to North American Rockwell Information Systems Co., NARISCO, (California). . . . installed at Philadelphia Electric Co. (Pennsylvania) as part of dispatch computer system developed by NARISCO . . . . DCTV provides operator/dispatch computer interface with greater accuracy, shorter response time, and more versatility, which decrease the chance of another major blackout. (Contractor, TEF 465, Case No. 86006, 2/73)

\* Denotes transfer case related to Key Issue.

#### D. ELECTRIC UTILITIES (CONT.)

- D-5 Atlas-Centaur rocket control system (mathematical model): developed for Lewis . . . . same group of experts used method to design control system for high temperature gas-cooled reactor (HTGR) at General Atomic Co. (California). . . . first commercial HTGR is 330-Mw Fort St. Vrain Plant for Public Service Company of Colorado, in operation late 1974. . . . significant advance in nuclear plant efficiency (40% versus 33% for water reactors) due to higher performance; HTGR required more sophisticated control system. (Personnel/contractor, TEF 446, Case No. 84984, 11/72)
- \*D-6 Fracture toughness tests (and analytic methods): developed by Lewis. . . . included in ASME Boiler and Pressure Vessel Code for nuclear power plant components. . . . used by major manufacturers to design nuclear plant equipment and steam turbines. . . . users include Westinghouse (Pennsylvania), General Electric (New York), Babcock and Wilcox (Ohio), Atomics International (California), General Atomic (California) and Combustion Engineering (Tennessee). . . . annual capital investment in nuclear power was \$3.5 billion in 1972 and 1973. . . . trend toward larger nuclear plant designs (200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). (Professional society, TEF 451, Case Nos. 85203, 85204, 85206, 85208, 85212, 86001, 1/73)
- D-7 Fatigue analysis methods: developed by Lewis. . . . included in ASME Elevated Temperature Design Code. . . . used by General Electric Co. (New York) for steam turbine design, Westinghouse (Pennsylvania) for steam turbine maintenance, General Atomic Co. (California) for high temperature gas-cooled reactor design, Combustion Engineering, Inc. (Tennessee) and Babcock and Wilcox Co. (Ohio) for electric power steam generator design. . . . provides better prediction of fatigue life from high temperature test data. (Professional society, TEF 450, Case Nos. 85202, 85207, 85213, 86000, 86002, 1/72)
- D-8 Apollo Program quality assurance specifications: (NPC 200-2) developed by Headquarters. . . . modified by DOD for military specs (MILQ 9853A) which in turn were largely incorporated by AEC (District of Columbia) in comprehensive quality assurance specs for nuclear plant licensing. . . . General Electric Co. (Florida) implemented Apollo specs under NASA contract, now offers Nuclear Quality Assurance Consulting Service to do same service for electric utilities with similar AEC specs. . . . four utilities and five nuclear plant contractors have used GE service on 12 nuclear plants, including Commonwealth Edison Co. (Illinois), Florida Power Co., and TVA (Tennessee). . . . Ontario Hydro (Canada), third largest electric utility in North America, 15,000-Mw capacity, is using NASA specs to develop own QA specs for contractors. (Interagency for AEC, contractor for GE, professional society for OH, TEF 444, Case Nos. 84976, 87032, 2/73)

\* Denotes transfer case related to Key Issue.

#### D. ELECTRIC UTILITIES (CONT.)

D-9 NASTRAM (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . used by General Atomic Co. (California) for dynamic modeling of high temperature gas-cooled reactors, Westinghouse (Pennsylvania) for designing nuclear power plants that will float offshore, and Hanford Engineering Development Laboratory (Washington) for fast breeder reactor design analysis. . . . provides unique capability for using computer in design analysis of large, complex structures. (Personal contact or professional journal/COSMIC, TEF 410, Case Nos. 84977, 84981, 86003, 1/73)

#### Other Relevant Examples:

B-6 (gas turbine electric generators); E-7 (coal mine reclamation);  
E-10 (coal desulfurization); G-2 (power plant siting maps); G-3,  
G-7 (hydroelectric plant scheduling and planning)

## E. ENVIRONMENTAL QUALITY

### Key Issues

- a. Carbon monoxide pollution in urban areas: a study recently published by the Medical College of Wisconsin showed that three-fourths of those persons examined in Denver, Los Angeles, and Chicago had blood concentrations of carbon monoxide above 1.5%, the level set as harmful by federal standards. A National Academy of Sciences report estimated that in urban areas 4,000 deaths and 4 million illness-related days from work were due to auto air pollution. (E-1)
- b. Vehicle emission standards and certification: New car emission standards have increased average cost of pollution control devices from \$17 in 1968 to \$115 in 1974 to estimated \$246 for 1975 models. New vehicle certification requires vehicle emissions of hydrocarbons, carbon monoxide, and nitrogen oxides to meet EPA standards using EPA-approved testing procedures. States are developing programs for annual emission inspection of all vehicles. (E-2)

## E. ENVIRONMENTAL QUALITY

- \*E-1 Skylab carbon monoxide monitor: developed for Ames. . . . commercialized by Andros, Inc. (California) as air pollution monitor. . . . now sold by Beckman Instruments (California). . . . unique design features allow accuracy and portability. . . . instrument certified by EPA. . . . over 30 sold @ \$6,800 to air pollution agencies and companies. . . . used to measure carbon monoxide pollution in urban areas, such as the CO profile over Los Angeles. (Contractor, TEF 481, Case No. 93827, 10/73)
- \*E-2 Hazardous gas analyzer for Saturn rocket: developed for Marshall. . . . adapted by Chrysler Corp. (Alabama) to develop product line of vehicle exhaust analyzers. . . . over 70 large units sold @ \$15,000-\$50,000. . . . provides simultaneous measure of CO, CO<sub>2</sub> and hydrocarbons. . . . allows automated testing. . . . analyzer accepted as legal alternative standard by EPA and California for vehicle emission certification testing. . . . used by Chrysler (Michigan) for new vehicle certification (heavy duty engines) and quality control during production. . . . used by Chrysler (California) for 2% Quality Audit of new cars, a California requirement (3,000 cars/year, \$600,000 test facilities). . . . also used to trouble-shoot defective vehicles, reducing labor costs at least 50%. . . . Chrysler's portable exhaust analyzer product used for state inspection by garages and car dealers. . . . over 1,000 small units sold @ \$1,600. (Contractor, TEF 486, Case No. 93832, 9/74)
- E-3 Filter cassette for sampling particulate pollutants: designed and produced for Lewis air pollution program in Cleveland by General Metal Works, Inc. (Ohio). . . . commercialized by contractor. . . . \$25 cassette widely sold for pollution monitoring stations. . . . considered by pollution experts to be best cassette on market. . . . prevents sample contamination during transport to and from monitoring stations. (Contractor, TEF 493, Case No. 99658, 6/74)
- E-4 Satellite telemetry systems: developed for Goddard by General Electric Co. (Pennsylvania) for Nimbus and ERTS-1. . . . used by GE to develop state-wide computerized air pollution monitoring network (COPAMS) for Pennsylvania. . . . 32 stations to implement air quality laws. (Contractor, TEF 483, Case No. 96532, 2/74)
- E-5 Weather satellite data: program managed by Goddard. . . . used by National Weather Service to forecast wind conditions. . . . forecasting used by state air pollution agencies (Colorado and others) for air stagnation maps and air pollution dispersal conditions. . . . dispersal prediction crucial for implementing pollution control sequence (advisory, alert, warning, emergency). (Interagency, TEF 26, 194, Case Nos. 78001, 96526, 10/73)
- E-6 ERTS-1 imagery: program under Goddard supervision. . . . imagery used by scientists at University of Vermont to identify and map major pollution plume in Lake Champlain caused by paper mill. . . . partial basis for legal action by State of Vermont against paper mill and State of New York. . . . ERTS imagery and interpretation of imagery accepted as legal evidence in case after review by Supreme Court-appointed master. . . . one of first pollution cases involving state vs. state accepted by Supreme Court. (Contractor, TEF 500, Case No. 101911, 9/74)

• Denotes transfer case related to Key Issue.

## E. ENVIRONMENTAL QUALITY (CONT.)

- E-7 Aircraft remote sensing program and imagery: program by Johnson. . . . infrared photographic imagery of Midwest used in 1971 by Purdue University (Indiana) and U.S. Department of Agriculture to analyze spread of corn blight. . . . Indiana portion of imagery used by Earth Satellite Corp. (District of Columbia) to map and measure coal mine refuse piles. . . . maps now used by Indiana legislature in preparing legislation on reclamation of mine refuse sites. . . . 200 sites larger than 2 acres each were identified and reclamation cost estimate exceeded \$14 million. (Contractor, TEF 199, Case No. 101912, 9/74)
- E-8 Remote sensor for air pollutants: operational prototype developed for Johnson. . . . correlation spectrometer sold by Barringer Research, Ltd. (Canada). . . . over 40 sold @ \$23,000. . . . unique air pollutant measuring capability. . . . measured NO<sub>2</sub> profiles over Los Angeles and San Francisco, SO<sub>2</sub> profile over Chicago. . . . also used by air pollution agencies in U.S., Canada, Australia, Japan, France, Spain. (Contractor, TEF 482, Case No. 95608, 8/73)
- E-9 Computer models for Apollo Program: developed for Johnson. . . . used by TRW Systems (California) to develop more than 30 air and water quality models. . . . provided technical basis for implementing pollution laws in Alaska, California, D.C., Ohio, South Carolina, Vermont. (Contractor, TEF 487, Case No. 96531, 1/74)
- E-10 Lunar module rocket engine test facility: developed for Johnson. . . . used by TRW Systems (California) to develop inexpensive coal desulfurization process. . . . EPA funding at \$1.5 million for research and pilot plant design. . . . process could eliminate need for expensive stack gas removal equipment for electric utilities. . . . SO<sub>2</sub> pollution control a critical financial problem for coal-fired power plants. (Contractor, TEF 488, Case No. 96530, 9/74)
- E-11 Computerized image enhancement: developed by Jet Propulsion Laboratory (California) to process digitized image transmissions from unmanned spacecraft (e.g., Ranger and Mariner). . . . used by JPL in current program to develop computer processing of water quality data from ERTS-1 multispectral digitized imagery. . . . joint funding by TUO and EPA (Oregon) to obtain cheaper, more efficient method for classifying quality of inland lakes in National Eutrophication Survey (NES). . . . good correlation between JPL results and EPA's water sampling data. . . . EPA initiated NES in 1972 to determine lake deterioration caused by phosphorus materials in sewage plant effluent. (Contractor/Applications Engineering Project, TEF 520, Case No. 104142, 10/74)

### Other Relevant Examples

B-13 (noise pollution, fan noise reduction method); D-1 and D-2 (air pollution control for power plants); D-8 (nuclear safety); G-1 (new sewage treatment method); G-2, G-3, G-5 and G-6 (water quality and supply data); H-1 (reduced offshore oil pollution); H-7, H-10 and H-11 (reduced air pollution for refinery, gasoline bulk stations and engine fuels); K-2, K-4 and K-5 (reduced automobile emissions)

## F. FOOD PRODUCTION AND PROCESSING

### Key Issues

- a. Productivity: over last century, mechanization made possible a ten-fold decrease in farm workers needed to feed U.S. (47% of work force in 1870, 4% in 1970). Farm crop output per man-hour increasing at annual 10% (versus 3% national average); a major factor is improved equipment. In 1960, 40% of tractors were 60 hp. or less; in 1972, two major producers (Deere and Allis-Chalmers) introduced new models over 150 hp. which increase productivity 10-20% by pulling standard implements faster or pulling larger implements. (F-2)
- b. Food products merchandising: continuing developments in merchandising--rigorous quality assurance, improved inspection programs, and open-dating of packaged, perishable food goods--have permitted the \$119 billion U.S. food industry (meat packing \$26 billion) to provide quality food for consumers. Average U.S. family spent 15.9% of its after-tax income on food in 1973. (F-8)

## F. FOOD PRODUCTION AND PROCESSING

- F-1 Weather satellite imagery and ground receiver: developed for Goddard. . . . used by National Marine Fisheries Service (California) for 25% of input to daily fishery advisory charts for eastern Pacific. . . . charts sent by radio facsimile to entire U.S. tuna fleet in Pacific. . . . reduced time and fuel costs for locating tuna, help avoid adverse weather. . . . annual Pacific tuna catch worth over \$75 million, provides 90% of tuna canned in U.S. (20% of U.S. fish consumption is canned tuna). (Interagency, TEF 194, Case No. 78002, 8/74)
- \*F-2 Fracture toughness tests: developed by Lewis. . . . used at Deere and Co. (Illinois) to improve safety and service life of products (snowmobiles, farm tractors and implements). . . . reduced fracture failure of snowmobile drive trains, tractor roll-over protection systems (ROPS). . . . ROPS required by OSHA, Deere selected steel on basis of fracture tests. . . . 20% of research department effort on these applications. . . . Deere introduced new 150 hp. tractor in 1972, increased productivity 10% by pulling large implements or same implements faster. . . . implement service life not decreased, partly due to improved fracture toughness matching higher performance (e.g., plow striking rock could have caused brittle fracture). . . . Deere annual sales over \$1 billion, about 25% of farm machinery market. (Professional society, TEF 451, Case No. 101903, 8/74)
- F-3 Precipitation-hardened steel alloy: developed for Johnson (Apc'lo Command Module) by Armco Steel. . . . Armco alloy used by Hopper, Inc. (California) in fabricating Ram-Jet, wind machine for frost protection in noncitrus orchards (apples, almonds, etc.). . . . @ \$7,000. . . . several hundred operating in Washington, Oregon and California. (Contractor, TEF 223, Case No. 42553, 8/74)
- F-4 Contamination control handbook: compiled for Marshall. . . . used at USDA Research Center (Louisiana) for training employees and research. . . . recommended by USDA to food processing firms with contamination problems. . . . one research application was developing a process for converting cottonseed pulp to high protein (67%) flour for human consumption. . . . due to contamination problem, pulp from cottonseed oil production mainly used for cheap animal feed. . . . new process solves problem and one cottonseed mill already producing the more profitable flour. (TB/TSP, TEF 262, Case No. 31762, 8/74)
- F-5 Clean room technology: developed for Johnson by Pillsbury Co. (Minnesota) . . . . Pillsbury originally installed clean rooms, conducted employee training programs, and compiled a contamination control management practices manual for astronaut food production facility. . . . technology applied in all new food processing facilities at Pillsbury, clean rooms are installed in some older facilities, and all employees receive contamination hazards training . . . . improved product quality and reduced product recalls due to contamination. . . . management manual (720 pages) is publicly available and used by FDA (District of Columbia) to train federal food inspectors. (Contractor, TEF 503, Case No. 101910, 8/74)

\* Denotes transfer case related to Key Issue.

F. FOOD PRODUCTION AND PROCESSING (CONT.)

- F-6 Microbiological handbook: compiled for Marshall. . . . used by Kraftco Corp. (Illinois) as training manual for sanitary techniques in food processing plants and in research. . . . used by USDA scientists (Missouri) in development of improved milk processing procedures and equipment now used in dairy industry. . . . valuable reference in both cases. (TB/TSP, TEF 402, Case Nos. 51578, 51786, 9/74)
- F-7 Nondestructive spot test procedure: compiled by Langley. . . . used by Kraftco Corp. (Illinois) for alloy identification when analyzing chemical reactions for food, atmosphere, and stainless steel processing equipment combinations. . . . time and money saved when reaction problem occurs and must be eliminated to avoid food contamination. (TB/TSP, TEF 378, Case No. 47744, 8/74)
- \*F-8 Electronic strain gage: invented by founder of BLH Electronics. . . . improved and standardized by BLH for space program which was the first major market . . . . used by field centers (Goddard, Lewis and Marshall) and contractors in most rocket engine R&D projects and space vehicles such as the surveyor lunar lander. . . . commercial markets developed by BLH for standardized products. . . . product used by Armour and Co. (Illinois) in Armour Tenderometer since 1969. . . . unique capability to test hanging carcass and accurately predict meat tenderness after cooking, not possible previously. . . . Armour selects and guarantees all TesTender beef with instrument. . . . amount of premium-priced TesTender beef sold annually is tens of millions of pounds . . . . Armour was awarded 1973 Food Technology Industrial Achievement Award for Tenderometer, a major innovation in beef merchandising. . . . cattle growers using the instrument data for selective breeding programs. (Customer/subcontractor, TEF 505, Case No. 101898, 103418, 10/74)
- F-9 Compressed/freeze-dried food: developed for Johnson. . . . marketed by Innovative Foods (California) as compact emergency food rations. . . . used by hunters, backpackers, etc. . . . sales expected to reach approximately \$1 million within a year. (Personal contact/contractor, TEF 502, Case No. 101896, 8/74)
- F-10 Eutectic salts for low temperature batteries: developed for Goddard by Artech Corp. (Virginia). . . . used by Artech to develop Irreversible Warmup Indicator. . . . shows, by color change, whether frozen foods have defrosted during transportation or storage. . . . 3 million sold, total sales \$100,000. (Contractor, TEF 504, Case No. 101897, 8/74)
- F-11 Cooling system for Gemini space suits: developed for Johnson by Garrett Corp. (California). . . . adapted by Garrett to develop galley refrigeration system for commercial aircraft. . . . used by Western Airlines. . . . total sales about \$500,000, 50 units installed. (Contractor, TEF 228, Case No. 100430, 8/74)

Other Relevant Examples:

G-6 (flood forecasting); K-3 (farm tractor design)

\*Denotes transfer case related to Key Issue.

## G. GOVERNMENT

### Key Issues

- a. Sewage treatment facilities: EPA's Needs Survey for 1973 set the costs for new water treatment equipment between 1973 and 1990 at \$61.7 billion to satisfy the water quality requirements in the Water Pollution Control Act of 1972. This represents a three-fold increase over the 1971 cost estimate (\$18.1 billion) which was based on previous, less stringent water quality standards. Two major cost factors in the new projection are secondary treatment facilities (\$17.1 billion) and new sewer systems (\$24.5 billion). Costs to be shared by federal (75%) and local governments (25%). (G-1)
- b. Natural resource management: Revenues from natural resources managed by all levels of government were \$3.67 billion in 1971 (\$3.33 billion from federal resource leases, water projects, etc.). All government expenditures for natural resources and the environment were \$11 billion in 1965 (includes \$1.73 billion by state/local) and \$13.7 billion in 1971 (includes \$3.67 billion by state/local), with about 6% for capital outlays. These expenditures covered such areas as land, watershed, and wildlife management, as well as pollution and flood control. Federal aid to state and local governments for resource management increased rapidly from \$300 million in 1965 to \$1.33 billion in 1973. There is a critical need at all government levels for better resource information at lower cost to support the government management efforts required by recent environmental legislation. (G-2)

## G. GOVERNMENT

- \*G-1 Pyrolytic synthesis of activated carbon: developed for Headquarters by Jet Propulsion Laboratory (California) to prepare rocket insulation. . . . used by JPL, under NASA contract, to develop novel sewage secondary treatment pilot plant. . . . 10,000-gal./day plant converts sewage to activated carbon by pyrolysis. . . . carbon then used to remove organics from primary treatment water, to increase raw sewage settling rates by 100-fold, and to fuel pyrolysis process. . . . minimizes solid waste disposal, eliminates odors, and removes most heavy metal pollutants from waste. . . . effluent will satisfy 1983 water quality requirement set by Water Pollution Control Act of 1972 at a lower total cost than less satisfactory secondary treatments currently used. . . . pilot plant now operated by Orange County Sanitation District (California), with NASA and county funds (\$200,000), to develop scale-up design data. . . . county is developing one million-gal./day prototype plant on cost-sharing basis (county 12.5%, state 12.5%, EPA 75% of \$3.4 million). . . . will determine feasibility and design criteria for combining new process with primary treatment plants nationwide. . . . EPA estimates that \$17.1 billion will be spent on new secondary treatment plants by 1990. (Contractor, Client/contractor, TEF 516, Case Nos. 103403, 103404, 10/74)
- \*G-2 ERTS-1 imagery: program under supervision of Goddard. . . . used by Ohio to construct maps utilized for power plant siting, forest inventory, and pollution and resources management of Lake Erie shoreline. . . . Georgia has a continuing program to utilize ERTS-1 imagery; applications have included a state map (effort took one man-week to prepare; comparable map using ground survey estimated @ over \$1 million and several man-years) used for farm pond and earthfill dam inventories; also being used to map coastal marshland for a comprehensive marshland protection program. . . . being used in Utah for map preparation, a hydrologic survey, and wild life assessment to develop state management policies for the Great Salt Lake area; also used to prepare a map of Tooele County for land use planning, with current application in zoning and identifying new recreation areas. (Contact/federal agency, Contractor, TEF 500, Case Nos. 101904, 101913, 101925, 101928, 9/74)
- G-3 ERTS-1 data collection system: developed by Goddard. . . . used by U.S. Geological Survey (Florida) to telemeter hydrologic data from 20 key remote Data Collection Platforms in southern Florida. . . . only feasible way to obtain data consistently on a near real-time (less than 1 hr.) basis. . . . data used in water management for 1,500 miles of canals and hundreds of control facilities to supply the water needs of southern urban areas, Everglades, wildlife preserves. . . . rapid monitoring critical for flood control (hurricanes) and maintaining water quality during storm water runoff. . . . USGS ordered 35 more DCP's for southern Florida network. . . . used by Department of the Environment (Canada) to telemeter river discharge data from remote areas subject to intense cold. . . . high quality data obtained at low annual maintenance and operating costs (less than \$100/station, cheaper than radio by a factor greater than 10). . . . data used for flow and flood forecasting, design of future hydroelectric power plants, pollution control. . . . Dept. of Environment quadrupling (9 to 40) number of DCP's. (Interagency, TEF 509, Case No. 101930, 9/74)

\* Denotes transfer case related to Key Issue.

#### G. GOVERNMENT (CONT.)

- G-4 Computer programs for ERTS-1 data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . being used by Texas Water Development Board under contract to U.S. Army Corps of Engineers, Nashville District (Tennessee), to analyze ERTS-1 imagery for verification of dam inventory in Tennessee. . . . accurately identifies water bodies over 10 acres . . . . reduces verification cost by factor of 10. . . . may be used to verify inventories in other states after Tennessee trial. . . . dam inventory is part of federally funded Program of Inspection of Dams authorized by Congress in response to dam failures at Buffalo Creek, West Virginia and Rapid City, South Dakota. . . . hundreds died in these disasters. (Interagency, TEF 513, Case No. 101905, 9/74)
- G-5 Skylab photography: program under supervision of Johnson. . . . used in NASA-funded EREP experiment by U.S. Geological Survey (Florida) with computer processing to construct detailed hydrologic map of Florida's Green Swamp area. . . . swamp is headwaters for 5 rivers which are critical for water needs of central Florida. . . . map shows well-, moderately and poorly drained land in entire swamp (8,000 sq. miles). . . . key factor in facilitating amicable out-of-court settlement of multimillion dollar suit between State of Florida and land developers by showing which areas could be developed without damaging water supplies . . . . Florida Dept. of Natural Resources providing funds to publish the map for land use management. (Interagency, TEF 508, Case No. 101929, 9/74)
- G-6 Slidell computer complex: established by Marshall for production management and checkout of Saturn rocket. . . . a major computer facility in south central U.S. . . . since 1971, also used by National Weather Service to forecast flow and stages of all major rivers in five state area (Mo., Ark., Tenn., La., Miss.) . . . . large, third generation computer essential for digital simulation model forecasting (first use of this technique by NWS) which provides 72-hour forecasts accurate within 0.3 ft. . . . forecasts important for flood control; also used by farmers and shippers. . . . other agencies using computer facility include Corps of Engineers (Red River sedimentation analysis), U.S. Geological Survey (environmental studies), National Park Service (user study of Great Smoky Mountains National Park). (Interagency, TEF 506, Case No. 101926, 9/74)
- G-7 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . process control technology used to design memory system for new post office automated parcel sorting equipment . . . . reduced cost of parcel sorting, high speed and reliability. . . . Chrysler units worth about \$500,000 already installed at 3 post office. (Binghamton, N.Y., Greensboro, N.C. and Chicago, Ill.). . . . 2 more on order for California and Postal Service planning additional installations. . . . data acquisition technology used in automated system for real-time collection and processing of hydrometeorological data from Columbia River Basin for Bonneville Power Administration. . . . 43 data gathering stations linked by microwave and VHF radio to master station in Portland. . . . system used for flood control, management of water and forest resources, and providing data from computing hydroelectric plant generating schedules. (Contractor, Customer/contractor, TEF 507, Case Nos. 101923, 103405, 9/74)

## G. GOVERNMENT (CONT.)

- G-8 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL, under contract to TUO and Los Angeles Comprehensive Health Planning Council, to develop local health care planning computer model. . . . integrates demographic, health, health services and other data. . . . provides better projection of hospital bed requirements than HEW planning model which is now used nationwide by states and local councils to allocate hospital construction funds from HEW . . . . successful application by JPL of model within LA council area. . . . California evaluating model for statewide use in place of HEW model. (Contractor, TEF 514, Case No. 103401, 9/74)
- G-9 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . four aerospace companies (Northrop Corp., Science Applications, Inc., Aerojet-General Corp., and Lockheed Missiles and Space Co.) are paired with four cities (Anaheim, Fresno, Pasadena, and San Jose). . . . each company provides its paired city with a Science and Technology Advisor and technical support. . . . eleven formal projects undertaken, as well as informal consultation and advising. . . . program has caused city management consideration or use of new devices and methods, including public safety hardware, planning software, system management and integration approaches, and variety of management technique improvements. . . . ongoing or completed management applications include cable television franchise negotiations, municipal waste, vehicle replacement scheduling, and computerized Municipal Information System. . . . cities achieving considerable cost savings and operational improvements, with quantified savings from only two projects estimated at more than \$600,000. . . . program currently being extended to additional cities, with coordination through the League of California Cities. (Contractor, TEF 512, Case No. 101115, 9/74)
- G-10 Apollo Management Control Room. designed for Kennedy by Midwest Research Institute (Missouri). . . . used by MRI as a model to design a management control room for Kansas City officials overseeing construction of the \$200 million city airport. . . . project so successful, design of 3 additional control centers funded by city and other local government agencies: Jackson County (Missouri) Courthouse, Alcohol Safety Action Project, and City Council Goals and Progress Center. (Contractor, TEF 510, Case No. 101924, 9/74)
- G-11 Space simulation chamber: developed and maintained for Johnson by McDonnell Douglas Corp. (Missouri) for Mercury and Gemini programs. . . . used by MDC to restore water damaged records with heating/freeze-drying process. . . . restored more than 20% of 20 million records destroyed or damaged by 1973 fire at Military Personnel Records Center (Missouri). . . . large cost savings by reducing the number of records that must be reconstructed from other sources . . . . restoration was not possible without chamber. . . . Center normally uses records to process 9,000 requests daily concerning retirement benefits, entitlements, etc. . . . MDC received \$400,000 for military records restoration and \$200,000 from 10 subsequent restoration contracts. (Contractor, TEF 511, Case No. 101914, 9/74)

G. GOVERNMENT (CONT.)

G-12 Nondestructive spot test procedure: compiled by Langley. . . . frequently used by Occupational Health Dept., State of New York Labor Dept., to perform screening tests on samples from companies during investigations of health or safety hazards. . . . provides rapid, inexpensive pretest before more detailed test procedures. . . . investigation results are basis for recommending changes to companies and possible legal action to force elimination of hazards. (TR/TSP, TEF 378, Case No. 44526, 8/74)

G-13 Fireman's breathing apparatus: developed by Johnson and its contractors using extravehicular life support system technology. . . . funded by TUD . . . prototype equipment includes a high pressure air compressor, air tanks, face masks and harnesses. . . . NASA unit is smaller, lighter, more convenient, and capable of longer use between refills than commercially available units. . . . 20 prototype units being field tested by fire departments in Houston, New York City and Los Angeles. . . . several firefighting equipment manufacturers considering new products based on the NASA design. (TUO-Applications Engineering, TEF 519, 10/74)

Other Relevant Examples:

C-2 (fire fighting equipment); C-7 (U.S. Coast Guard life raft); D-3 (Bonneville Power Administration control system); D-8 (AEC licensing regulations); E-4, E-5, E-8 and E-9 (air quality agencies); E-6 (state vs. state case); E-7 (state legislature); E-11 (EPA National Eutrophication Survey); F-1 (National Marine Fisheries Service); F-4 and F-6 (USDA food processing); F-5 (FDA training manual); H-1 (USCG regulations); I-3 (HUD Operation Breakthrough Program); I-6 (New York City sewage system); I-7 (U.S. Army Corps of Engineers dam projects); J-1, J-3 and J-4 (police departments); J-2 (LEAA information system); K-1 (state highway departments); K-2 (DOT Urban Systems Program/local traffic departments)

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## H. PETROLEUM AND GAS

### Key Issues

- a. Offshore oil production: 176 billion bbl. of oil and 248 trillion cu. ft. of gas have been discovered on worldwide continental shelves, with vast areas still unexplored. Offshore oil production in 1970 was 1.6 million bbl./day for U.S. and 7 million bbl./day worldwide; U.S. production remained the same in 1973, and world production increased to 10 million bbl./day. Pollution from offshore production became major environmental issue in 1969 with Exxon Co. well blow-out in Santa Barbara Channel off California. U.S. offshore industry and regulatory agency, U.S. Geological Survey, improving safety and antipollution regulations in response to public pressure. U.S. leasing was accelerated in 1973. (H-1)
- b. New gas supplies: In 1970, U.S. consumed 23.4 trillion cu. ft. of gas; approximately 95% of this was natural gas produced in U.S. Gas is the premium fossil fuel since it is easy to transport, clean burning and almost pollution free. If supplies were available, 1980 consumption would be 35.8 trillion cu. ft. Estimated that only 24 trillion cu. ft. of natural gas will be produced in 1980, shortfall of 11.8 trillion cu. ft. Synthetic gas production facilities and LNG import terminals are being developed rapidly to improve gas supplies in U.S. Additional 1980 gas supplies projected at 2.1 trillion cu. ft. syngas and 1 trillion cu. ft. LNG imports. U.S. has 2 operating LNG import terminals, 5 under construction and 6 more planned. (H-2)

## H. PETROLEUM AND GAS

- \*H-1 Reliability and quality assurance methods: developed by Marshall. . . . used by Marshall, under contract to U.S. Geological Survey (District of Columbia and Louisiana), for 1971 study of functional reliability for safety and anti-pollution equipment on offshore oil/gas production and drilling platforms . . . . basis for improved assurance by federal government and industry that offshore oil and gas will be produced safely and with minimal pollution. . . . . over 4,000 copies of report distributed to offshore industry worldwide by USGS . . . . USGS regulates all offshore operators on U.S. Outer Continental Shelf, including 1,800 drilling and production platforms in Gulf of Mexico. . . . new Recommended Practices issued by American Petroleum Institute (Texas) for subsurface safety valves and surface safety systems based on Marshall recommendations. . . . will be adopted by industry and included in USGS regulations . . . . will require licensing of equipment manufacturers in 1975. . . . additional API RP's based on Marshall study being prepared. . . . Offshore Operators Committee (Louisiana) designed computerized, industry-wide failure reporting system based on Marshall recommendation, and USGS is reviewing system before actual development and implementation. . . . Exxon Co. (Texas) and other offshore companies made equipment and operating changes to improve safety and reduce pollution hazards based on the study. (Interagency for USGS, Contact/USGS for API, Offshore Operators Committee and Exxon, TEF 484, Case Nos. 93829, 93830, 93831, 8/74)
- \*H-2 Cryogenic transfer system cooldown: data and analytic methods developed for Space Nuclear Propulsion Office and Lewis (NERVA Engine Program). . . . used by Chicago Bridge and Iron Co. (Illinois) to design piping systems at most large LNG import terminals in U.S. . . . . cooldown rate of warm pipes at start of flow is a critical design parameter. . . . provided major input to CBI design of \$7 million ship-to-shore LNG transfer system at Distrigas Corp. (Massachusetts) import terminal. . . . first (1971) major LNG import facility in U.S. (over 3 billion cu. ft. storage capacity). . . . also used by CBI to design ship-to-shore piping for Algonquin LNG, Inc. (Rhode Island, 6 billion cu. ft. storage in 1973), Columbia LNG Corp. and Consolidated System LNG Co. (Maryland, 5 billion cu. ft. storage in 1976). . . . U.S. annual LNG imports were 2 billion cu. ft. in 1971 and projected to be 2 trillion cu. ft. in 1980. (NBS Cryogenic Data Center, TEF 364, Case No. 50868, 8/74)
- H-3 Insulation technology for Saturn rocket: developed for Marshall by Rockwell International Corp. (California). . . . RI licensed polyurethane insulation technology to Wanner-Isofi Co. (France) for worldwide LNG storage installations and NHK Spring Co. (Japan) for LNG tankers. . . . NHK is major corporation diversifying into shipbuilding. . . . RI conducts tests and provides consulting for licensees. . . . U.S. Coast Guard completing tests for RI prototype WET WALL Insulation System design for LNG tankers. . . . major development program for advanced marine insulation system. . . . expected advantages are significantly lower capital and operating costs, increased volumetric efficiency and improved maintainability. . . . probable license or joint venture with U.S. shipbuilder after Coast Guard approval which is required for designs used in hazardous cargo tankers. (Contractor, TEF 361, Case No. 50221, 9/74)

\* Denotes transfer case related to Key Issue.

## H. PETROLEUM AND GAS (CONT.)

- H-4 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and interface equipment for computerized control systems for oil field production, oil and gas pipelines. . . . major international supplier of such systems, over 3 dozen major oil and gas company customers. . . . provides "real-time" monitoring and control from central station. . . . high-speed data transmission over voice grade circuits between central station and remote terminals is innovation in supervisory control systems. . . . computer systems replacing intermediate-level automation. . . . field production benefits through reduced operating cost and increased production. . . . Exxon Co. (Texas) has computer production control (mostly TRW) in 20 major U.S. fields (200,000 barrels oil and 850 million cu. ft. gas, daily) and estimates 1-2% production benefit. . . . other customers include Continental Oil Co. (Louisiana and California), Getty Oil Co. (Texas), Imperial Oil, Ltd. (Canada), Mobil Oil Corp. (Oklahoma, California, Louisiana, Pennsylvania), National Iranian Oil Co. (Iran), Shell Oil Co. (Louisiana, Venezuela), and MAPCO, Inc. (Oklahoma). (Contractor, TEF 465, Case No. 86005, 8/74)
- H-5 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Texas). . . . used by SCI in remote data acquisition and control systems product line. . . . systems installed on oil and gas pipelines and oil field production equipment. . . . provides better centralized monitoring and control, with less manpower. . . . 50 installations worldwide, 30 in U.S. (Contractor, TEF 119, Case No. 4793, 9/74)
- H-6 Heat pipe technology: developed for Marshall, Langley, and Ames by McDonnell Douglas Corp. (Washington) for Skylab, shuttle and unmanned satellites. . . . commercial heat pipe products developed by MDC include Cryo-Anchor soil stabilizers to prevent thawing of permafrost under structures in far north. . . . eliminates serious foundation stability problem. . . . MDC received \$13 million contract from Alyeska Pipeline Service Co. (Alaska) to supply over 100,000 Cryo-Anchors for \$5 billion Alaskan pipeline. . . . will be installed around pipe supports for 390-mile elevated portion of 800-mile pipeline. . . . Cryo-Anchors are 2" or 3" in diameter and range in length from 30 to 60 ft. (Contractor, TEF 197, Case No. 86008, 8/74)
- H-7 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product used for maintenance inspections at petrochemical plants and refineries by Allied Chemical Corp. and American Oil Co. (Texas). . . . Amoco remotely detects weak links, leaks, and off-specification equipment temperatures to determine maintenance problems. . . . improved plant efficiency and reduced pollution. . . . widespread interest in scanner by oil refineries caused by Amoco success. (Customer/contractor, TEF 398, Case No. 70001, 8/74)
- H-8 Hot tapping method for pipes: developed for Johnson. . . . included in maintenance manuals used at all American Oil Co. (Indiana) refineries. . . . Amoco fabricated related equipment. . . . previously, pipe or valve leaks required up to 8 people and either partial shutdown or elaborate safety procedures. . . . new method done by one or two people in half the time, with no shutdown and little fire hazard. . . . refinery may have about six serious leaks annually. (Trade Journal/TSP, TEF 460, Case No. 75018, 9/74)

## H. PETROLEUM AND GAS (CONT.)

- H-9 Nondestructive testing training manuals: developed for Marshall. . . . manuals published by contractor and distributed by American Society for Nondestructive Testing. . . . used by Mobil Oil Corp. (New Jersey) to train new employees in maintenance inspection procedures for refineries. . . . improved training and saved time in preparing instructional materials. . . . Mobil has 10 refineries in U.S. (Professional society/contractor, TEF 14, Case No. 53789, 9/74)
- H-10 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Edwards Engineering Corp. (New Jersey) to select special refrigeration oil and vendor. . . . solved major lubrication problem in using off-shelf compressor for very low temperature condenser component in new Edwards product and reduced product cost. . . . unique product automatically recovers gasoline vapor at bulk distribution stations, in compliance with air pollution standards, and conserves gasoline. . . . @ \$125,000, three installed and 40 on order. . . . very rapid market growth expected to continue. . . . all major oil companies have ordered at least one. . . . pay-back time to customer is 2-3 years. (Trade Journal/TSP, TEF 497, Case No. 97902, 9/74)
- H-11 Combustion analysis computer program: developed by Lewis. . . . used by Phillips Petroleum Co. (Oklahoma) to generate chemical equilibrium composition tables for all combustion research projects. . . . saved 3 professional man-years for program development and additional time for each application . . . . applied to reduce air pollution from fuel products during car engine combustion, from in-house incinerators, and from in-house burning of waste gases. (Lewis conference, TEF 463, Case No. 93825, 12/72)
- H-12 Systems safety technology (and other technology related to pipeline safety): developed by several NASA field centers. . . . Regional Dissemination Center provided information to Mechanics Research, Inc. (California). . . . used to prepare proposal for the U.S. Dept. of the Interior (District of Columbia) for Alaskan pipeline safety project. . . . \$18 million contract awarded in 1974. . . . information extremely important to Mechanics Research, estimated value over \$100,000. (RDC-WESRAC, TUO case, 9/74)

### Other Relevant Examples:

B-10 (LNG tankers); I-6 (LNG storage facilities)

## I. CONSTRUCTION

### Key Issue

Construction project management: total new construction in 1973 was \$130 billion, including \$53 billion for residential buildings, \$26 billion for nonresidential buildings, and \$14.9 billion for public utilities. Material and equipment supply bottlenecks are increasing, which adds to the normal scheduling problems and costly delays. 1965 survey of construction industry indicated a widespread opinion that the Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) would soon become necessary for success in construction contracting. 1972 construction industry survey revealed that only 14% of respondents were successful in applying these advanced management techniques in spite of the widespread interest. Two major obstacles were psychological factors and the cost, in time and money, for generating the necessary network graphics. Computerized methods to use PERT conveniently and cheaply eliminate these obstacles, and applications have been increasing since 1972. (I-1)

## I. CONSTRUCTION

- \*I-1 NASA Pert computer program (Program Evaluation and Review Technique): developed by Marshall. . . . used by Systonetics, Inc. (California) as principal part of computer service for project scheduling in construction and other industries. . . . program widely used by customers; also available from other service companies and used in-house by some construction firms. . . . since there is no charge for NASA PERT, each user saves about \$500/month compared to alternative software available commercially. . . . Systonetics combined NASA program with in-house program, EZPERT, that automatically generates graphic output. . . . significant additional savings from combined programs due to automated output of network activity graphics (\$.32 @ and 200 activities printed/hour compared to \$3.60 @ and 10/hour for manual production). . . . combined programs from Systonetics used routinely since 1972 by Associates Corp. (Indiana), a Gulf and Western subsidiary in consumer finance field, for many management functions. . . . applications include scheduling modifications or new construction in nationwide branch office system (over 900 offices), corporate planning, modeling accounts receivable and minority affairs programs. . . . very important part of multimillion dollar management system that enables company to come within 10% of time and cost estimates for projects. . . . Associates also using programs to assist South Bend (Indiana) in airport expansion project. (Personnel/contractor, Customer, TEF 517, Case Nos. 103406, 103407, 9/74)
- I-2 Geodesic structure design program: developed for Headquarters by R. Buckminster Fuller at Southern Illinois University. . . . computer program used by Dome East Corp. (New York) to design commercial geodesic structures. . . . applications include recreational enclosures, greenhouses, homes and medical clinics. . . . 1973 sales \$320,000. . . . \$500,000-\$1 million sales anticipated for 1974. . . . first domes made with plastic and vinyl coverings, but Dome East now experimenting with solid, laminated panels. (Personnel/grantee, TEF 479, Case No. 91454, 8/74)
- I-3 Reinforced plastic structures: initial work under DOD contracts. . . . development continued for Headquarters, Langley, and Lewis for high performance rocket motor cases, stabilizers, and liquid hydrogen pressure containers. . . . new plastic materials commercially used by Materials Systems Corp. (California) to fabricate wall panels for prefabricated housing. . . . plastic made from petroleum refinery wastes. . . . company, which was formed by aerospace engineers in 1970, holds contract with HUD-Operation Breakthrough Program. . . . currently building 1,100 units in California, 200 in St. Louis, @ \$5,000. . . . over 10% cost savings compared to conventional factory-built housing. . . . additional installations in Mexico, France and Iran. (Personnel/contractor, TEF 518, Case No. 103411, 9/74)
- I-4 Fiberglass fabric: invented by Owens-Corning Fiberglas Corp. (Rhode Island) . . . . company developed first application for fiberglass fabric with 1967 contract from Johnson for nonflammable clothing and structures; included development of Teflon coating for fabric. . . . coated fabric used commercially in air structures developed by Birdair Structures, Geiger-Berger & Assoc. (New York) and others. . . . installations include a vinyl-coated fiberglass fabric covering for the U.S. Pavilion at Expo 70 in Osaka, Japan, and the more commonly used Teflon-coated fabric coverings for stadiums and arenas. . . . \$10 million/year industry. (Contractor, Customer/contractor, TEF 324, Case Nos. 103412, 103413, 103414, 9/74)

\* Denotes transfer case related to Key Issue

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## I. CONSTRUCTION (CONT.)

- I-5 Instrumentation electronics for Saturn rocket: developed for Marshall by SCI Systems, Inc. (Alabama). . . . design techniques and production methods used by SCI to design a ground fault interrupter that will fit inside a standard home circuit breaker. . . . interrupter prevents electrical accidents in home by tripping circuit breaker when ground fault current occurs. . . . required for all new homes in U.S. by 1971 Electric Code amendment. . . . normal annual rate of two million housing starts. . . . SCI sold 40,000 interrupter units/month before recent housing slump, market expected to improve. (Contractor, TEF 119, Case No. 4793, 9/74)
- I-6 Cryogenic data handbook: developed for Kennedy. . . . used by Mason & Hanger-Silas Mason Co. (Kentucky), a major civil engineering firm, to design low temperature construction projects. . . . applications include at least 4 LNG storage facilities and a refrigeration system for freezing wet, loose ground during excavation in major New York City sewage system project. . . . provided 50% of input to solving serious problem in refrigeration system. . . . also used to identify substitutes for scarce materials used for corrosion control in acid plants and pollution abatement equipment. (TB/TSP, TEF 248, Case No. 9562, 8/74)
- I-7 Fusion welding workmanship standards: compiled for AEC and NASA Space Nuclear Propulsion Office. . . . used by Gannett, Fleming, Corddry, Carpenter (Pennsylvania), a major civil engineering firm, to develop acceptable weld methods and to qualify welders for dam contractors. . . . saved about \$250,000 on \$50 million Foster Joseph Sayers Dam project (Pennsylvania) for Army Corps of Engineers. . . . current applications for Tioga/Hammond Lakes Dams, also part of Corps program in Susquehanna River basin. . . . flood control and dilution of acid drainage from coal mines. (Contact/DOD, TEF 86, Case No. 28474, 9/74)
- I-8 Heat shield coating for reentry vehicles: coating composition patented by Emerson Electric Co. (Missouri). . . . first market was space program applications; coating properties determined by qualification tests conducted for NASA field centers, including Johnson and Langley. . . . coating sublimates when heated and protects substrate from high temperature. . . . Emerson employees who developed coating formed Thermo Systems, Inc. (Missouri) in 1967. . . . TSI acquired patent rights on coating line THERMO-LAG. . . . commercial market for THERMO-LAG in construction industry is growing very rapidly. . . . reliable, effective, inexpensive fire retardant coating that protects high-rise building components, such as structural steel and electrical cables, during fires. . . . significant advance in commercially available coatings . . . . structural steel coating .2-inches thick will give two-hour fire protection comparable to four inches of concrete coating. . . . applications include high-rise motels (Florida), a pharmaceutical building (Missouri), and chemical plants (California, Texas, Colorado, Connecticut). (Personnel/contractor, TEF 521, Case No. 104141, 10/74)

### Other Relevant Examples:

B-11 (chemical plant design); D-9 (nuclear power plant design); G-10 (airport construction management); H-2 (LNG import facilities)

## J. LAW ENFORCEMENT

### Key Issue

Computerized police information systems: The first real-time police computer system was installed in 1964 for the St. Louis department. In a 1971 survey of almost 500 police departments, 38.8% of the responding departments were using computers and 62.5% would be using computers by 1974. Applications include police patrol inquiries on wanted status of individuals or property ownership, automated traffic violation records, patrolman dispatching, automated files for criminal investigations, allocation and distribution of regular patrol units, and crime statistics. The Law Enforcement Assistance Administration (LEAA) has provided federal funds to police departments for computer acquisition. Police efficiency has been improved in some, but not all, instances. In addition, a controversy exists over cost effectiveness of computer use. (J-1)

## J. LAW ENFORCEMENT

- \*J-1 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets, video output is of professional quality . . . . total sales \$23 million. . . . most sales to law enforcement agencies, including Royal Canadian Mounted Police (\$1.1 million system in 1971), Illinois Bureau of Criminal Investigations (\$1.2 million, 1972), and Louisville Police Department (Kentucky, 1973). . . . provides compact, automated fingerprint file system used successfully in all installations and criminal history files (including photographs) in some installations. . . . Canadian system will pay for itself in 3 years by reducing cost of fingerprint searches. (Contractor, TEF 226, Case No. 66201, 9/74)
- J-2 Scientific and Technical Information Management System (STIMS): developed for the Scientific and Technical Information Office, NASA Headquarters, as a computer software package for storing and retrieving bibliographic materials . . . . obtained from STIF by the Law Enforcement Assistance Administration, Dept. of Justice (District of Columbia). . . . became the primary operating software for the National Criminal Justice Reference Service, a central computerized information system serving the nation's law enforcement and criminal justice agencies. . . . NCJRS (became operational in September 1972) has 30,000 registered users and performed over 300,000 searches in 1973. (Personal contact, TEF 515, Case No. 103402, 9/74)
- J-3 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL Public Safety Program, under contract to Los Angeles Police Department, for requirement definition and design of proposed city-wide emergency command and control communications system. . . . includes master radio network plan, systems design for computer-assisted dispatching, automated vehicle monitoring, automated mobile command center, automated precinct command center, out-of-car communications network, and detailed specifications for mobile digital communication system. . . . will be first totally integrated system in country (cost to install over \$50 million). . . . being established under LEAA funding as model program. . . . consortium of major cities established to facilitate subsequent technology transfer. (Contractor, Contact/contractor, TEF 514, Case Nos. 103399, 103400, 9/74)
- J-4 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . Aerojet-General Corp. providing Pasadena with a Science and Technology Advisor and technical support. . . . Advisor used systems analysis to help Pasadena Police Department in selecting site for city heliport used by police helicopter, in compiling operations manual for effective helicopter patrol, and in developing program that reduced false alarms from burglary/robbery detection systems by 40%. (Contractor, TEF 512, Case No. 101915, 9/74)

\* Denotes transfer case related to Key Issue.

**J. LAW ENFORCEMENT (CONT.)**

**Other Relevant Examples:**

B-13 (OSHA noise regulations); D-1 (air pollution standards); E-2 (vehicle emission certification); E-4, E-9 and H-10 (implementing air quality laws); E-6 (legal evidence); E-7 (preparing environmental legislation); F-2 (OSHA safety regulations); G-5 (environmental lawsuit); I-5 (electrical code requirements)

## K. HIGHWAY TRANSPORTATION

### Key Issue

Highway safety: Total economic loss due to highway accidents in 1972 was almost \$19 billion. 1972 accidents caused 56,000 deaths and 4,850,000 injuries. California has largest number of fatalities, almost 10% of total. Accident rate per 100 million vehicle miles decreased from 5.5 in 1965 to 4.5 in 1972, an 18% reduction. (K-1)

## K. HIGHWAY TRANSPORTATION

- \*K-1 Highway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . Langley results were basis for new highway/airport grooving industry with about \$2 million annual business. . . . firms include Pavement Specialists, Inc. (Texas), Cardinal Engineering (Pennsylvania), Transportation Safety Systems, Inc. (Ohio), San Diego Concrete Cutting Co. (California), Charles R. Watts Co. (Washington), and C. W. Hatcher, Inc. (California). . . . over 25 states have contracted to have dangerous highway sections grooved. . . . wet highway accidents on grooved sections reduced by about 60%. . . . about 20% of accidents occur on wet pavement. . . . California Department of Transportation is leading user, with \$8 million total outlay; applications include 400 miles of freeway grooved in Los Angeles area. . . . General Electric Co. (Ohio) produces artificial diamonds used in manufacture of groover cutting blades. . . . GE actively promoting grooving. (Contact/Langley, TEF 168, Case Nos. 101917, 101919, 101920, 101921, 101922, 9/74)
- K-2 Apollo Guidance Computer software: developed for Johnson by TRW Systems (Texas). . . . used by TRW Systems (California) to develop first, real-time computerized traffic control system in U.S., SAFER (Systematic Aid to Flow on Existing Roadways). . . . prototype TRW SAFER installed and operating in 9-mile square South Bay area of Los Angeles County (California). . . . project cost about \$800,000; funded by U.S. Department of Transportation Urban Systems Program (71%), County of Los Angeles (22%) and State of California (7%). . . . more than 15% reduction in millions of vehicle hours spent waiting at 112 South Bay traffic lights. . . . estimated total annual savings to motorists using South Bay streets is \$1 million. . . . projected total annual savings if SAFER were installed county-wide would be \$50 million. . . . TRW also installing SAFER in Baltimore, Maryland (1,000 traffic lights) and Overland Park, Kansas. (Contractor, TEF 465, Case No. 103415, 8/74)
- K-3 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . used by Ford Motor Co. (Michigan) for design analysis of car, truck, and farm tractor components since 1971. . . . more than 40 design engineers trained to use program. . . . influenced design of every major component in these products. . . . saved two-thirds of calculating time in achieving 60% improvement for component behavior predictions. . . . reduced R&D time and cost, as well as development testing costs (no valid cost savings figure available at this time). . . . General Motors Corp. (Michigan) recently completed development of design application methods to facilitate NASTRAN use by design engineers. . . . program calibrated with data from older vehicles. . . . corporate effort aimed at widespread use of NASTRAN in product design. . . . NASTRAN versatility and continued program maintenance service from Langley are very important to Ford and GM. (Contact/COSMIC, TEF 410, Case Nos. 103416, 103417, 9/74)

\* Denotes transfer case related to Key Issue.

## K. HIGHWAY TRANSPORTATION (CONT.)

K-4 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . electronics design, computer, systems, and quality production experience at Huntsville Div. used to develop new products and production line testing for most Chrysler cars and trucks . . . . annual production 2 million units. . . . product applications include hybrid circuitry in new solid-state radios for Plymouth and Dodge lines, accurate digital clock for Chrysler line, and ignition retarder to reduce emissions when idling. . . . more durable radio uses 20% of electricity previously required. . . . production applications include methods to produce reliable electronic ignition systems used in all cars and light trucks, automated electrical wiring test system for some car assembly plants, computerized system for automated testing of car distributors and windshield wiper motors, and semiautomated test system for brake cylinders. . . . electronic ignition system is a major improvement in car equipment, better car performance reduces emissions and lowers maintenance cost. . . . 60-second test of car wiring identifies whether rework is needed. . . . 8,000 distributors tested daily at 60 secs. each, with 10 times previous accuracy. . . . brake cylinders tested in 7 secs. (Contractor, TEF 507, Case No. 101927, 9/74)

K-5 Combustion analysis computer program: developed by Lewis. . . . routinely used by General Motors Corp. (Michigan) since 1970 in combustion research for automotive engines. . . . by modeling the engine combustion process, program improved analysis of how pollutants are formed. . . . research results used in various GM design and development projects. . . . used extensively by Chrysler Corp. (Michigan) in combustion analysis for gas turbine engine development. . . . gas turbines will be introduced in 1975 automobiles. . . . lower emissions and fewer moving parts than standard piston engines. (Contact/Lewis, TEF 463, Case Nos. 103409, 103410, 9/74)

### Other Relevant Examples:

A-1 and A-6 (automobile products); B-9 (lubricant for car air conditioners); E-2 (vehicle emission certification); H-11 (vehicle emission control)

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